

BLADELESS TURBINE - A REVIEW

Vishwam Shah

Mechanical Engineering, U.G. Student, Gujarat Technological University, India

Shyam Dhokai

Mechanical Engineering, U.G. Student, Gujarat Technological University, India

Pratik Patel

Mechanical Engineering, Assistant Professor, Gujarat Technological University, India

ABSTRACT

Nikola Tesla invented this bladeless turbine (patented 1913) originally, which uses boundary layer effect to run and not impingement of fluid upon the blades as in conventional. There are number of discs sequentially mounted on a shaft and the fluid is made to flow in a tangential direction with considerable pressure onto the discs with the help of an efficient nozzle, then follows a spiral path towards the centre and exits axially. The discs rotate due to the basic properties of the fluid – viscosity and adhesion, as momentum is transferred via this forces and kinetic energy of fluid is converted into the rotational energy of the shaft. Many researchers have studied this concept and given various improvements with proofs basically into two ways – one suggesting modifying the design of various components involved while others to change the parameters involved.

Key words: Bladeless Turbine, Boundary Layer, Plenum Chamber, Viscosity, Adhesion

Cite this Article: Vishwam Shah, Shyam Dhokai and Pratik Patel, Bladeless Turbine - A Review. *International Journal of Mechanical Engineering and Technology*, 8(2), 2017, pp. 232–236.

<http://www.iaeme.com/ijmet/issues.asp?JType=IJMET&VType=8&IType=2>

1. INTRODUCTION

During flight of an aircraft at very high speeds, there is a thick layer of air which sticks to its wings. This layer of air also travels at same speed as that of the airplane. Above this thin layer, there is a shear plane separating this boundary layer from the rest of the still air. A drag is formed at this shear plane due to this thin layer and if eliminated it could increase the plane's speed up to 40%. But Tesla viewed it in a totally opposite manner and thought it could be useful.

Now, when a fluid is made to flow across a solid surface a thin layer of fluid in the immediate vicinity of the surface is in contact with it where the velocity of the flow varies from zero at the surface up to its original flow velocity. This thin layer of fluid is called boundary layer and the effect produced by it is called boundary layer effect. Here, in Tesla turbine as the fluid enters on the periphery of the discs which are mounted in parallel

to one another very closely, the fluid forms a boundary layer between the two discs and at such high velocity it spirals around turning the discs and finally the turbine.

2. BACKGROUND

The foremost patent for the design was registered by the Nikola Tesla in 1913 which led to a great revolution in turbo machinery sector. After that not much research was done in this area until 1950 when a revival of interest was seen ^[1]. Tesla's work has been characterized by a number of researchers among which Rice's analysis was the first and it claimed that this turbine can attain up to 90% efficiency ^[2]. Ho-Yan and Lawn claims that they can make this turbine work to reach 70% efficient ^[3]. Micro turbine designs were tested and verified by Hoya, Guha, and Smiley who claimed 25% efficiency by computational models and analysis ^{[4][5]}. As the size of the turbines becomes smaller, the frictional considerations become an important factor and it should be determined accurately. The surfaces that have a relative roughness higher than 0.05, value of flow constriction become important which was argued by Kandlikaretal. He was able to do that by modifying the original moody diagram ^[6]. Gumrat reported that Poiseuille number increases with surface roughness and also providing the detailed summary of the previous work ^[7]. The vast majority of the experimental results published utilize air as the working fluid. It is the author's opinion that the best opportunity for the Tesla turbine to gain significance would be related to steam or particulate laden fluid applications. In particular, low quality steam power generation would be an ideal situation. There is a definite lack of published experimental data where the working fluid is steam of any quality. Most of the studies done until now on this Tesla turbine are basically based on intuition or simple experience or some empirical calculations. Much attention to detail is required in this topic for more accurate analysis of the factors contributing to its performance.

3. LITERATURE REVIEW

Professor Warren Rice in 1965 devised a turbomachinery with the rotor composed with smooth disks and conducted several experiments and published its results showing performance and efficiency of the multidisc turbine. **James H. Armstrong** in June 1952 did an investigation on the performance of modified tesla turbine by suggesting several areas of improvement which could increase its efficiency. He did experiment in three groups: First using a short pipe of 1/8 inch for nozzle. The second group was with several nozzles with diverging sections and the final group of tests consisted of economy runs at 7,000 rpm using nozzle which had produced the highest outputs of the turbine previously ^[8]. **Aaron Peshlakai** in 2012 presented a thesis on the variation of working fluid used and its effect on the turbine performance. He used compressed air, saturated steam and water for his turbo assembly analysis. The results indicate that the turbine is capable of achieving a turbine efficiency of $31.17 \pm 3.61\%$ and a rotor efficiency of 95 ± 9.32 ^[9]. **Vedavalli Gomatam Krishnan** in his dissertation on design and fabrication of cm-scale turbine in 2015 discusses the scaling characteristics of Tesla turbines and also offers design solutions for achieving optimum performance given the input specifications. He has taken for his experiment, 1 cm diameter rotors with the variation in number of disks, spacing in between them and the effective area and the turbine casing with eight nozzles with varying area, angle and shape ^[10]. **A Guha and B smiley** studied and experiment the reason behind low efficiency of Tesla turbine. They developed a new nozzle with plenum chamber which had less than 1 percent loss in it as compared to 13-14 percent loss previously. They were also able to increase more uniformity of the flow of jet. ^[11]

4. PARAMETERS AFFECTING PERFORMANCE

4.1. POWER

Tesla turbine is best suited for low power generation spectrum or where primary cost is critical or where fluid properties hinder the performance of conventional turbine. The power output throughout the literature has shown as low as in milliwatt while the notable values are around 1kw to 2kw. Still, most of the results obtained are about under 500 watts but that can be improved largely according to theory.

4.2. NOZZLE

For the same pressure drop, diverging nozzle produces about one-third more horsepower than the straight nozzle.

It is an impulse turbine as all the expansion of steam occurs in the nozzle only rather than onto the rotors (as a result of which the exhaust holes are placed as nearer to the centre of the rotor).

Main drop in the overall efficiency is seen due to the less efficiency of the nozzle. This problem can be solved however by using plenum chamber which increases the stability and uniformity of the jet flow before entering into the nozzle.

The exact nozzle angle for highest efficiency is not known but the angle at which the flow hits the turbine tangentially covering maximum area of the disk is considered optimum.

4.3. FLOW CHARACTERISTICS

Presence of the turbulent flow conditions at the transition from laminar to turbulent till mid turbulent gives the best power output i.e. the Reynolds number approximately 450,000. (Medium- compressed air)

4.4. FRICTION FACTOR

Poiseuille number increases with the surface roughness. (By Gamarat)

This increase in the number is of substantial help here as it improves the performance of the rotor as the primary force of running the turbine is shear force.

The second benefit of increasing the roughness is the increase in the momentum transfer of the fluid to the discs thereby increasing the drag force and faster the tangential velocity drop. ^[12]

Spiral grooves on the turbine have proved to increase the efficiency of the turbine drastically. ^[13]

Bladeless turbine works efficiently at surface roughness of value (Ra) 500 microns on disk surface. ^[13]

4.5. RPM

Effectiveness of operating the turbine can be maximized by running at a lower rpm and more flow rate. This increases the momentum transfer of the fluid to the discs.

4.6. INTERDISK SPACING

Torque and power are found to increase by decreasing spacing between the disks up to 0.5mm ^[13]. This spacing can be more optimized but according to experimental results the minimum ratio of the rotor's radius to the inter-disc spacing should be 20. ^[12]

According to Warren Rice, the highest efficiency is seen the turbine when the distance between the disks is equal to two times the boundary layer thickness.

4.7. NUMBER OF DISKS

By increasing the number of disks, the surface area on which the fluid flows increases thereby increasing the torque acting and hence the efficiency. Most of the experiments have been carried out by taking 6 to 10 disks in general. Though there is no specific consideration on the number to be fixed as it depends on several other conditions like the power output required, number of nozzles used inter disk spacing and also the pressure of the working fluid used.

5. SUMMARY

At large power requirements, the performance of bladed turbines outruns the bladeless turbine. However, bladeless turbines are highly efficient in small power generations.

However, its efficiency can be improved dramatically if more research be dedicated to it.

If proper discrimination is done by comparing the results against changing certain parameters or improving a particular condition then we can establish few scenarios according to which there surely will be a growth in its efficiency.

We can say that by keeping the nozzle divergent and minimizing the radial force to zero or almost zero can a condition to optimum growth.

Turbulent flow increases the efficiency of the turbine as compared to laminar flow.

Friction improves the efficiency of the turbine to a very large extent as it provided more momentum to the disks.

Minimum ratio of the rotor's radius to the inter disk spacing should be 20. Also, we can decrease the spacing up to 0.5mm for the optimum conditions.

REFERENCES

- [1] May, P., Tesla, N., & York, N. E. W. (1913). » N. Tesla.
- [2] W. Rice, "An Analytical and Experimental Investigation of Multiple Disk Turbines," Journal of Engineering for Power, vol. 87, pp. 29-36, 1965.
- [3] Ho-yan, B. P. (2011). Tesla Turbine for Pico Hydro Applications, (4), 1–8.
- [4] S. B. Guha A., Experiment and analysis for an improved design of the inlet and nozzle in Tesla disc turbines, Journal Power and Energy, 224 (2), pp. 261- 277, 2009.
- [5] G. A. Hoya G. P, The design of a test rig and study of the performance and efficiency of a Tesla disc turbine, Proceedings of the Institution of Mechanical Engineers, Part A: Journal of Power and Energy, Volume 223, pp. 451-465, 2009.
- [6] Taylor, J. B., Carrano, A. L., & Kandlikar, S. G. (2006). Characterization of the effect of surface roughness and texture on fluid flow — past , present , and future ☆, 45, 962–968. <http://doi.org/10.1016/j.ijthermalsci.2006.01.004>
- [7] Gamrat, G., Favre-Marint, M., Le Person, S., Baviere, R., & Ayela, F. (2008). An experimental study and modelling of roughness effects on laminar flow in microchannels. J. Fluid Mech, 594(October 2016), 399–423. <http://doi.org/10.1017/S0022112007009111>
- [8] Armstrong, J. H. (N.D.). An Investigation of the Performance of a Modified Tesla Turbine.
- [9] Bott, R. (2014). Challenging the Versatility of the Tesla Turbine: Working Fluid Variations and Turbine Performance. Igarss 2014, (1), 1–5.
- [10] Krishnan, V. G. (2015). Design and Fabrication of cm-scale Tesla Turbines, (October). <http://doi.org/10.1115/1.1413771>

- [11] Guha, A., & Smiley, B. (2016). Experiment and analysis for an improved design, 224, 261–277. <http://doi.org/10.1243/09576509JPE818>
- [12] Agrawal, S. K., Gardner, G., & Pledge, S. (2015). Design and Fabrication of an, 123(December 2001), 525–528. <http://doi.org/10.1115/1.1413771>
- [13] Barhm Abdullah Mohamad and Abdelsalam Abdelhussien, Failure Analysis of Gas Turbine Blade Using Finite Element Analysis. International Journal of Mechanical Engineering and Technology, 7(3), 2016, pp. 299–305.
- [14] K. Sunil Kumar, Dr. Sumathy Muniamuthu, S. Arun and A. Mohan, Identification Experimental Analysis of Noise and Vibration Reduction in Windmill Gear Box for 5MW Wind Turbine. International Journal of Mechanical Engineering and Technology, 7(6), 2016, pp. 76–85.
- [15] Rajasri Alloli, Pratibha Dharmavarapu and Chunchu Sravanthi, Design and Manufacture of Vertical- Axis Wind Turbine Based on Magnetic Levitation. International Journal of Mechanical Engineering and Technology, 7(6), 2016, pp. 86–95.
- [16] Borate, H. P. (2012). An Effect of Spacing and Surface Finish on the Performance of Bladeless Turbine, (1), 1–7. <http://doi.org/10.1115/GTINDIA2012-9623>.